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Investigating the invasion of the nonindigenous zooplankter, *Eubosmina coregoni*, in Lake Winnipeg, Manitoba, Canada

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ABSTRACT

The spread of nonindigenous species (NIS) over land and via interconnecting water bodies is threatening aquatic ecosystems worldwide. This study examines the invasion of the first known NIS zooplankter, *Eubosmina coregoni*, into Lake Winnipeg, Manitoba, Canada. Analyses of cladoceran microfossils from a sediment core collected in the North Basin of the lake indicate this species first appeared in sediments dated to the late 1980s. An increase in total cladoceran accumulation rates coupled with increasing N, C, P, and chlorophyll *a* over the last 40 years provides evidence of eutrophication. Extant samples from fall 2002-2005 indicate that *E. coregoni* is mainly restricted to the North Basin while *Bosmina longirostris* is present throughout the lake. Results from this study provide baseline data regarding the invasion and establishment of *E. coregoni*, a precursor to future NIS that may have substantial ecological and economic impacts on the Lake Winnipeg ecosystem.

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Introduction

The introduction of nonindigenous species (NIS) is an ongoing threat faced by aquatic ecosystems worldwide (Vitousek et al., 1997; Hall and Mills, 2000; Schindler, 2001). Over the last century, water bodies such as the Laurentian Great Lakes have received increasing numbers of NIS due to the discharge of ballast water (Mills et al., 1993; Ricciardi and MacIsaac, 2000). In contrast, lakes in Central Canada are more likely to receive NIS as a result of dispersal over land and via interconnecting river systems. The likelihood of NIS spreading to inland lakes has been modeled for the zebra mussel, *Dreissena polymorpha* (Buchan and Padilla, 1999; Allen and Ramcharan, 2001), and the spiny waterflea, *Bythotrephes longimanus* (MacIsaac et al., 2004). Many of the present invaders of the Laurentian Great Lakes are potential invaders of Lake Winnipeg. As Lake Winnipeg is used extensively for commercial and recreational purposes, it is essential to learn more about aquatic NIS in this water body and the vulnerability of this ecosystem to future NIS that have already had major economic impacts and have permanently changed the food web dynamics of the Laurentian Great Lakes.

Cladocerans (water fleas) such as *Bythotrephes longimanus* and *Cercopagis pengoi* are among the many successful NIS that have spread to inland water bodies after establishing in the Laurentian Great Lakes (MacIsaac et al., 1999; Makarewicz et al., 2001; MacIsaac et al., 2004). Cladocera, a major component of the microcrustacean fauna in freshwater lakes and ponds (Hann, 1989), possess a number of characteristics that enable them to be successful invaders. They mature rapidly and spend a large proportion of their lifetime as reproductive adults (Allan and Goulden, 1980), allowing them to establish quickly in aquatic ecosystems. Furthermore, most cladoceran species produce several generations of unfertilized eggs via parthenogenesis (Hann and Hebert, 1982) and diapausing, or resting, eggs via sexual reproduction during periods of environmental stress (Hann and Hebert, 1982; Hairston et al., 1995; Reid et al., 2000). As a result, both living individuals and diapausing eggs may be dispersed to new water bodies via transport by humans, animals, surface water (Frey, 1982; Shurin and Havel, 2002) or by wind (Cáceres and Soluk, 2002, Vanschoenwinkel et al., 2008).

Eubosmina coregoni Baird 1857 is the first known nonindigenous zooplankter to invade Lake Winnipeg. Common in water bodies of its native Eurasia (Lieder, 1991), *E. coregoni* first colonized the Laurentian Great Lakes in North America in the mid-1960s, likely transported in the ballast water of transoceanic vessels (Deevey and Deevey, 1971; Lieder, 1991). By the late 1960s, *E. coregoni* had dispersed to inland lakes within 100 km of the Laurentian Great Lakes (Deevey and Deevey, 1971) but was thought to be restricted to this region, potentially due to habitat constraints (De Melo and Hebert, 1994a). Mabee (1988) reported a southern range extension in Missouri for *E. coregoni*, and this species was detected in sediments dated to the early 1990s from Lake of the Woods, Ontario (Suchy and Hann, 2007). Salki (1996) found low numbers of *E. coregoni* (as *E. longispina*) in the 1994

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zooplankton community of Lake Winnipeg at two of 30 sampling sites: the Traverse Bay region (Winnipeg River inflow) in the South Basin and at the Nelson River outflow in the North Basin. Previous comprehensive zooplankton sampling throughout Lake Winnipeg in 1929 (Bajkov, 1934) and 1969 (Patalas and Salki, 1992) failed to uncover *E. coregoni*. From 1969 to 1994, zooplankton sampling was not undertaken on Lake Winnipeg, and it is conceivable that *E. coregoni* may have invaded the lake during this surveillance gap.

The present study uses microfossil remains from a Lake Winnipeg sediment core to reconstruct the invasion history of *E. coregoni* in order to address the gap in the zooplankton record. This paleolimnological approach provides a historical account of the arrival of *E. coregoni* and its subsequent development in the region. To examine the current spatial distribution of *E. coregoni*, zooplankton samples were collected by the Lake Winnipeg Research Consortium Inc. from lakewide sites during the 2002 to 2005 period. In addition, data concerning limnological conditions and other biological factors were collected at all sampling stations to examine whether a relationship exists between *E. coregoni* and these parameters. Ultimately, results from this study will provide a framework for future studies

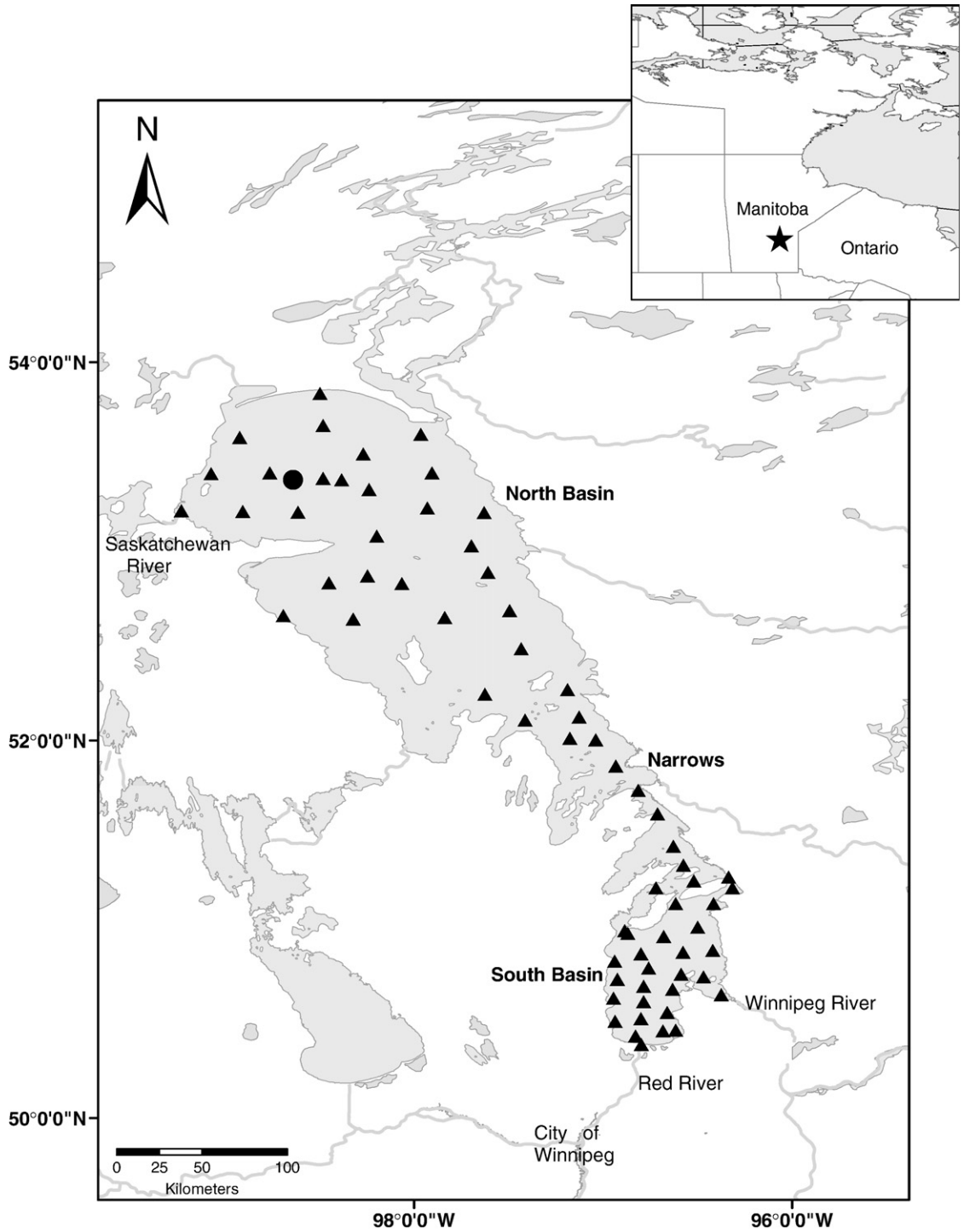

Fig. 1. Sampling stations for Lake Winnipeg, 2002–2005. Triangles indicate extant zooplankton sampling stations, circle indicates the location of the sediment core collected in 2003. Inset map shows location of Lake Winnipeg (star) within the province of Manitoba, Canada.

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